

From Operant Conditioning to Selection by Consequences

Julie S. Vargas
B. F. Skinner Foundation

The phrase "selection by consequences" appeared in the title of one of B. F. Skinner's publications for the first time in 1981. Skinner had discovered operant conditioning almost fifty years earlier. He did not talk about it as a selection process for many years. Why the delay? What contingencies over his behavior shifted to reveal parallels between operant conditioning and natural selection, and of "selection" as the process for cultural change? By looking at Skinner's research at different points in his career, some reasons can be inferred for his taking so long to describe behavioral change as a selection process.

Selecting requires two parts. The evolution of species requires a population of individuals from which selection occurs and the features that are, or are not selected. In the behavioral domain, a variety of actions must exist from which properties of behavior are selected. Selection cannot occur without existing variability. As Skinner pointed out, features of a species, of behavior, or even of a culture remain unchanged if either "no variations have occurred", or if "those which occurred were not selected by the prevailing contingencies (Skinner, 1981, p. 502)." Behavioral change requires an initial variability (Leao, M. d. F. F. C. et al. 2016).

In the early 1930s, Skinner began the research that led to his discovery of operant behavior. Unlike the respondents studied by Pavlov, operants were not responses to antecedent stimuli. Operant behavior was under postcedent control. Skinner differed from Pavlov in another way, too. Pavlov appealed to neurophysiological processes to explain his experimental findings. Skinner sought experimental conditions that when altered would change behavior without appealing to physiological or to hypothetical agencies. With behavior of rats providing the data, Skinner showed how different arrangements of postcedent contingencies determined the rate of bar-pressing. Unlike "trials" that stop the process of behavior for each trial, Skinner's experimental procedures showed uninterrupted actions as they occurred over continuous time. Rate, or probability of actions over time, became his dependent variable. Skinner eventually published the highlights of more than five years of his research in *The Behavior of Organisms*

(Skinner, 1991/1938). In this book, he mentions variability in the context of "drive" (p. 341). To Skinner, "drive" referred to the likelihood of a rat eating versus not eating food even when not having eaten for some time. There is no talk in the book about variability of the rat's behavior from which bar-pressing was selected.

In bar-pressing experiments Skinner did not need to consider variability of behavior. A bar-press is a common action for a rat. To produce a bar-press to reinforce, all Skinner had to do was to place a rat in his bar-press chamber and wait. The apparatus was wired so that a bar press operated the food-hopper. Sooner or later a bar press would occur and be automatically reinforced. In the research described in *The Behavior of Organisms*, it was *equipment* that presented food. Skinner arranged his equipment to deliver food under different contingencies of reinforcement. To be sure, the operant bar press was brought under an impressive array of contingencies, including discriminative control, but no new topography of behavior had to be shaped.

That changed in the 1940s, at the beginning of World War II. While riding on a train one day, Skinner was thinking about the war. Many pilots had been shot down trying to bomb German ships. For any real accuracy, they had to fly within reach of anti-aircraft guns. Out the window of the train, Skinner saw birds swooping alongside, flying with great accuracy. Suddenly he thought, "Could they not guide a missile?" (Skinner, 1979, p. 341). He was sure he could train birds to track ships even though no bird had ever dive-bombed ships before. Skinner began work, finally getting government funding for his project. He would have to teach new skills. As usual he and his coworkers set up equipment to deliver reinforcement in each step of this new project.

One day, bored with waiting for feedback from the government, Skinner and his assistants thought it would be fun to teach a bird to knock a ball around a box. They found a wooden ball about the size of a ping-pong ball. They would not have time to set up equipment for this diversion, so they rigged up a switch to operate the feeder by hand. To shape striking the ball sideways,

they had to watch everything the bird already did. They had to select an action to reinforce. Skinner described the training as follows (Skinner, B. F. (1979, p. 268):

We began by reinforcing merely looking at the ball, then moving the head toward it, then making contact with it, and eventually knocking it to one side with a swiping motion. The pigeon was soon batting the ball about the box like a squash player. We had shaped a very complex topography of behavior through successive approximation in a matter of minutes.

Skinner was amazed at how rapidly behavior changed! He had “discovered how much easier it was to shape behavior by hand than by changing a mechanical device” (Skinner, 1979, p. 268). See also Peterson, G.B. (2004), Skinner (1999/1972).

To create new actions with topographies never before seen, variability was needed. One property from among different actions had to be reinforced, and the criteria for selection had to shift as behavior improved. Now, without the need for equipment, shaping could be done with any animal anywhere!

As the war ended, Skinner thought about applying his science to cultural design. In *Walden Two* (2005/1948), he speculated on how a small community based upon behavioral principles could improve upon society at large. Though not specifically addressing variability, the book talks of diversity in member's skills and interests. Frazier, the designer who originally set up the community, attributes this variety mainly to members' leisure time, rather than to selective processes at work (126-128). Skinner wasn't talking about selection by consequences yet.

By 1948 Skinner had become a faculty member at Harvard University. A reporter from a popular magazine called *Look* heard about the technology called “shaping.” If shaping was so easy, could Skinner teach a dog to jump two feet off the ground while the magazine took photos? Here was a chance to demonstrate shaping, and Skinner had no hesitation. Of course he could teach a dog to jump! All he would need, he said, was a dog, food the dog particularly liked, and a scheduled time before the dog was usually fed. He would do the rest.

To shape a jump Skinner had to be able to reinforce immediately. There was no way food could reach the dog instantaneously as it moved about. He needed a conditioned reinforcer. In the hand-switch training of the pigeon, the sound of the food hopper opening was the conditioned reinforcer—the brief stimulus paired with food. Since a flash of light was needed for the

photographs, Skinner operated the flash as his conditioned reinforcer. In about 20 minutes, he shaped a jump with the dog leaping over a foot off the ground. The article, “Harvard-Trained Dog” came out in 1952 (*Look*, 1952). As with teaching a pigeon to knock a ball about, “successive approximations” were needed. Actions that were closer and closer to the desired performance had to be quickly reinforced.

At Harvard, Skinner was teaching a large undergraduate class. There was no textbook suitable for his course, so Skinner wrote his own, *Science and Human Behavior* (1953). Near the end of the text, Skinner talks about shaping as a selection process, drawing a parallel between operant conditioning and natural selection:

We have seen that in certain respects operant reinforcement resembles the natural selection of evolutionary theory. Just as genetic characteristics which arise as mutations are selected or discarded by their consequences, so novel forms of behavior are selected or discarded through reinforcement. There is still a third kind of selection which applies to cultural practices. (p. 430.)

Skinner soon addressed two cultural practices: verbal behavior and education. Skinner had been interested in language since graduate school days. He realized that principles derived from laboratory work did not apply only to animal shaping, but also to human behavior. Selection by consequences removed “free will” from all behavior. No internal agency stored memories, interpreted events, or made decisions. No homunculus was involved. Change in behavior was all the result of selection processes. The processes applied to social behavior as well as to individual actions.

With sabbatical leave in the spring of 1956, Skinner finally finished his book on language, *Verbal Behavior* (Skinner, B. F. 1992/1957). In it he wrote, “The formulation is inherently practical and suggests immediate technological applications at almost every step.” (Skinner, p. 12).

Skinner had already embarked on one “immediate technological application”. At a visit to his daughter's fourth-grade math class, he saw many students struggling to solve problems. He thought how easily skills could be taught with shaping. He realized, however, that with a class of many students, no teacher could present each next step just at the time that each student needed it. He would design a machine to help. It would do more than present material in small steps. Shaping required learners to constantly behave. Soon Skinner brought his own course material into a shaping format.

With Jim Holland, Skinner converted *Science and Human Behavior* into hundreds of steps (Holland & Skinner, 1961). They steps started with text blanks anyone could fill in and gradually increased the complexity of terms and analyses for students to write. Skinner assumed that feedback of being correct would function as reinforcement, and that seemed to work. With dozens of paper strips showing all the students' responses, Holland and Skinner revised each sequence until students went through the sequences successfully. Skinner called this verbal shaping "programmed instruction." It was selection by consequences of increasingly sophisticated verbal behavior.

SUMMARY

Selection requires a sophisticated analysis that is not intuitive. Even today, if you ask why a particular behavior such as a youngster's crying occurs, people look for antecedents. Perhaps they find a skinned knee, or they appeal to the antecedent of pain. Perhaps the child is said to be a "crybaby" or lacks self-esteem, both antecedent to the cry. By following a child around, one discovers postcedent controls: the crying occurs when followed by sympathy, but not where it has been ignored. The likelihood of a cry depends upon the history of selection of crying in the past.

It is not easy to observe the process of selection as it produces change. Darwin described how characteristics of animals arose from selective breeding, but he lacked early evidence for species like man. Skinner established the role of postcedents over the probability of specific actions, but his early experiments did not address new forms of behavior. It was when Skinner produced novel behavior by reinforcing only some of a pigeon's movements that he began writing about operant conditioning as a selection process. At all of Skinner's three levels, selection by consequences requires variability from which particular features survive to reoccur in the future.

re. New forms emerge, not from antecedent forces but from the postcedent events that select. Skinner's explanation excluded metaphysical antecedents like "free will" and other hypothetical internal agencies. Novel forms are explained in behavior as well as in biology by a process of selection by consequences.

REFERENCES

- Holland, J. G. and Skinner, B. F. (1961). *The Analysis of Behavior: A Program for Self-Instruction*. New York: McGraw-Hill.
- Leao, M. d. F. F. C., Laurenti, C., & Haydu, V. B. (2016, January 28). Darwinism, radical behaviorism, and the role of variation in Skinnerian Explaining Behavior. *Behavior Analysis: Research and Practice*. Advance online publication. <http://dx.doi.org/10.1037/bar00>
- Look. (1952, March 10). Harvard-Trained Dog.
- Peterson, G. B. (2004). A day of great illumination: B. F. Skinner's discovery of shaping. *Journal of the Experimental Analysis of Behavior* 82(3): 317-328.
- Skinner, B. F. (1953). *Science and Human Behavior*. New York: The Macmillan Company.
- Skinner, B. F. (1979). *The Shaping of a Behaviorist*. New York: Alfred A. Knopf.
- Skinner, B. F. (1981). The selection of behavior. *Science*, 213 (4507) pp. 501-504. Also in Skinner (1987) *Upon Further Reflection*. Englewood Cliffs: Prentice Hall.
- Skinner, B. F. (1991). *The Behavior of Organisms*. Cambridge, MA: Appleton-Century-Crofts. B. F. Skinner Foundation. (Original work published 1938).
- Skinner, B. F. (1992). *Verbal Behavior*. Cambridge, MA: B. F. Skinner Foundation (Original work published 1957).
- Skinner, B. F. (1999). Pigeons in a pelican. In *Cumulative Record: Definitive Edition*. Cambridge, MA: B. F. Skinner Foundation. (Original work published 1957).
- Skinner, B. F. (2005). *Walden Two*. Indianapolis, IA: Hackett Publishing Company. (Original work published 1948).

Artigo convidado
Recebido em: 20/07/2016

Note:

I would like to thank Ms. Monalisa Leao who, during her internship at the B. F. Skinner Foundation, drew my attention to the delayed appearance of "selection by consequences" in Skinner's publications.